DOCUMENT RESUME

ED 110 321 SE 018 902

AUTHOR Torop, William
TITLE An Analysis of Individualized Learning System Chemistry.
PUB DATE 17 Mar 75
NOTE 30p.; Paper presented at the annual meeting of the National Association for Research in Science Teaching (48th, Los Angeles, California, March 1975)

EDRS PRICE MF-$0.76 HC-$1.95 PLUS POSTAGE
DESCRIPTORS Autoinstructional Aids; *Chemistry; *College Science; *Computer Assisted Instruction; Educational Research; Higher Education; Individualized Instruction; *Instruction; Multimedia Instruction; Science Course Improvement Project; *Science Education
IDENTIFIERS ILS Chem; Research Reports

ABSTRACT

Individualized Learning System Chemistry (ILS Chem) is a multi-media approach to learning basic chemical principles and their application to man's daily existence in which the student proceeds at his own rate through a series of instructional loops. This is a computer-managed, competency-based instructional system in which the individual student is assigned learning experiences on the basis of his performance. This sequence of instructional loops, primary, remedial, and enrichment, may contain readings, audio or video tapes, field experiences, journal references, films or film loops, conferences, or computer-assisted instruction modules. The computer system also permits the random generation of comparable, criterion-referenced examinations and their scoring. The results of using this approach in Introductory Chemistry at West Chester State College during the past two years showed that the ILS Chemistry students consistently demonstrated a more favorable attitude toward both chemistry in general and their particular class than did the traditional chemistry students. There also exists evidence to suggest that ILS Chemistry students learned more chemistry than did their traditional counterparts in one evaluation and produced cognitive results at least as good as the traditional classroom in another evaluation. (Author)

****
* Documents acquired by ERIC include many informal unpublished *
* materials not available from other sources. ERIC makes every effort *
* to obtain the best copy available. nevertheless, items of marginal *
* reproducibility are often encountered and this affects the quality *
* of the microfiche and hardcopy reproductions ERIC makes available *
* via the ERIC Document Reproduction Service (EDRS). EDRS is not *
* responsible for the quality of the original document. Reproductions *
* supplied by EDRS are the best that can be made from the original. *
****

U S DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION
THIS DOCUMENT HAS BEEN REPRO
DUCED EXACTLY AS RECEIVED FROM
THE PERSON OR ORGANIZATION ORIGIN
ATING IT POINTS OF VIEW OR OPINIONS
STATED DO NOT NECESSARILY REPRE
SENT OFFICIAL NATIONAL INSTITUTE OF
EDUCATION POSITION OR POLICY

ED110321

AN ANALYSIS OF INDIVIDUALIZED LEARNING SYSTEM CHEMISTRY

by

William Torop

Professor of Chemistry
West Chester State College
West Chester, Pennsylvania 19380

PERMISSION TO REPRODUCE THIS COPY-
RIGHTED MATERIAL HAS BEEN GRANTED BY
William Torop
TO ERIC AND ORGANIZATIONS OPERATING
UNDER AGREEMENTS WITH THE NATIONAL IN-
STITUTE OF EDUCATION FURTHER REPRO-
DUCTION OUTSIDE THE ERIC SYSTEM RE-
QUIRES PERMISSION OF THE COPYRIGHT
OWNER

Contributed Paper

National Association for Research in Science Teaching

March 17, 1975

Los Angeles, California

SE 018 902

SYNOPSIS

ILS Chem - Individualized Learning System Chemistry - is a multi-media approach to learning basic chemical principles and their application to man's daily existence in which the student proceeds at his own rate through a series of instructional loops. This is a computer managed, competency based instructional system in which the individual student is assigned learning experiences on the basis of his performance. This sequence of instructional loops, primary, remedial and enrichment, may contain readings, audio or video tapes, field experiences, journal references, films or film loops, conferences, or computer assisted instruction modules. The computer system also permits the random generation of comparable, criterion-referenced examinations and their scoring.

The results of using this approach in Introductory Chemistry at West Chester State College during the past two years showed that the ILS Chemistry students consistently demonstrated a more favorable attitude toward both chemistry in general and their particular class than did the traditional chemistry students. There also exists evidence to suggest that the ILS Chemistry students learned more chemistry than did their traditional counterparts in one evaluation and produced cognitive results at least as good as the traditional classroom in another evaluation.

Introduction

ILS Chem - Individualized Learning System Chemistry - is a personalized, multi-media systems approach to learning basic chemical principles and their application to man's daily existence in which the student proceeds at his own rate through a series of instructional loops. ILS Chem was implemented in the 1973-1974 academic year at West Chester State College by Professor William Torop in the Chemistry 100 course known as Chemistry and Man. Che 100 is a one semester, four credit course in the fundamentals of inorganic, organic and biological chemistry applied to the contemporary problems of mankind. A terminal course for non-science majors which satisfies the general education requirement for science, it is also a required course for the health and physical education majors at West Chester.

The students are quite varied in their backgrounds - more so

than most other courses in science at the college. Most have had high school chemistry but many have not. As a competency based instructional system, the students with some previous knowledge of chemistry can satisfy all or part of the course requirements by examination. Most of the students are freshman but there are sophomores, juniors and seniors in the same sections as well. Although most students are health and physical education majors, they include elementary education majors as well as liberal arts majors in many different fields.

The individual student is assigned learning experiences relevant to his needs on the basis of his performance on criterion-referenced diagnostic tests. These assignments are described in a series of eight units or Individualized Learning System (ILS) Pacs prepared by Professor Torop. The sequence of instructional loops, primary, remedial and enrichment, may contain readings from several textbooks, in-Pac readings, self-tests with answers, audio or video tapes, field experiences, journal references, films or film loops, student-initiated or instructor-initiated conferences, or computer assisted instruction (CAI) modules. The forty-two CAI modules are both tutorial and simulation exercises designed to give additional practice, tutorial aid, and laboratory experiences. They are designed to supplement the system of individualized instruction. They may allow the student to bypass some topics, delve deeply into some topics, and obtain as much drill and practice as the student desires in each area. The modules are for the student's benefit and any lack of success in using the tutorial practice modules will not materially detract from his grade.

ILS Chem Pacs

The first ILS Pac, Student Directions (Pac 0), introduces the student to the ILS Chemistry system, computer directions, course requirements and the grading system. The eight course units are:

Pac 1 - Measurement: scientific notation, metric system, temperature scales and density.

Pac 2 - Terminology: matter, properties and changes, classification of matter, symbols, energy and the nature of science.

Pac 3 - Structure: atomic theory and structure, the mole concept and the periodic chart.

Pac 4 - Bonding: formulas, nomenclature, oxidation numbers and types of bonds.

Pac 5 - Reactions: equations, molecular weight, stoichiometry, percentage composition, reaction types, oxidation-reduction and rates.

Pac 6 - Solutions: acid-base theory, theory of ionization and stoichiometry.

Pac 7 - Carbon: comparison and distinguishing organic and inorganic compounds, bonding, identification, hydrocarbon nomenclature, reactions, functional groups, derivative nomenclature, cyclic compounds and heterocyclic compounds.

Pac 8 - Biochem: biochemical molecules and the environment.

The first page of each of these Pacs is a flowchart which depicts a guided sequence of instructional activites designed to provide information to the student when and only when he needs such instruction. Within the flowchart each instructional loop is

associated with a performance objective.

The second page of each ILS Pac contains the list of performance objectives for the Pac. Each objective includes the performance to be achieved, the conditions under which the performance is to be measured, and the minimum level of acceptable achievement. All Pacs begin and end with a computer generated, criterion-referenced, repeatable examination. The scope of each examination is defined by objectives in each ILS Pac.

The CMI System

The Computer Managed Instruction (CMI) system, prepared by Professor Thomas Egan, generates the criterion-referenced test items. The instructor sets up CMI to produce comparable examinations, each of which contains a predetermined number, but random, sample of questions from a test-item bank. The chemistry test-item bank, written by Professor Torop, currently contains over 2000 questions.

Students were originally allowed to take these comparable, computer-generated, criterion-referenced examinations as many times as they wish to achieve their desired level of proficiency--without the penalty of a lower grade for more than a single attempt. In the Spring of 1975 this was modified to a limit of three examinations plus a practice examination. Students still proceed at their own rate through the series of instructional loops. A competency-based, individualized approach to learning chemistry requires much bookkeeping, particularly when students are allowed to take these examinations at their convenience. CMI, therefore, also maintains statistics on each student, including where the student is in the course, how many times each examination

has been taken, the highest grade obtained for each comparable examination, and the student's examination average. The student enters his own answers to each examination except the course Final. Each computer-generated examination is supplemented by selected oral questions during the regularly scheduled conferences. The course Final, while also coomputer-generated and repeatable, is taken in a "normal," i.e., proctored test situation.

One concern of the instructor is losing personal contact with the students. For this reason the student and professor regularly meet on a one on one basis. Additionally, the computer system has a two-way message system which permits the professor and each individual student to leave messages for each other via the terminal. Finally, once-a-week class attendance is required.

CMI Details

CMI is a system for devloping computer managed instruction modules which requires no more knowledge of computing, on the part of the user, than how to log on. It should be stressed, nevertheless, that the ILS Chemistry Pacs do not require a computer for efficient use. However, the HP 2000 C computer is used at West Chester for appropriate functions. The instructor does not program the computer - he merely responds to questions asked by CMI, which is composed of a series of programs.

ILS builds and updates the flowchart. Tests can be specified as: on or off-line, computer or instructor generated, computer or instructor scored, with or without randomly generated items, whether retests are permitted (and if so do they retest all of the objectives or just the ones missed), whether or not the student or the instructor determines the minimum passing grade.

QUEST builds and updates test item data banks. Examinations permit usage of multiple choice, true-false, numeric (tolerances can be specified), completion or keyword search formats. Item analyses, including test item difficulty and discrimination indices, are maintained both on permanent and recent bases.

CLASS builds and updates student files. Statistics on student performance include flowchart location, dates and times of usage, number of times an examination has been taken, grades on examinations and student and class averages across examinations.

TEST will generate, alphabetically, examinations for all students in need of them .

MESAGE allows instructors to send messages to students.

INCRE will automatically allow the user to increase the size of any files.

CHANG provides security by allowing the change of codewords and file names if the need arises.

CMI is the only program used by the student. It is here that he receives and scores tests or is supplied with the information provided by his instructor. Through CMI he may also send messages to his instructor. To use this system, the student needs only to know the name of the program (CMI), the name of the student file (CHM100), and his I.D. number, as well as the log on number.

Procedure

The problem considered in this study was the relative effectiveness of an individualized approach to an introductory chemistry course, including a computer managed instructional system, and its effect on student attitude. The subjects for

the first part of this study, divided into two treatment groups, were the 167 college students enrolled in Che 100 at West Chester State College during the Fall Semester of 1973. The experimental group consisted of the thirty students who completed the ILS course taught by Professor Torop.

The control group consisted of the three regular sections of the course which were taught by three different instructors in a traditional lecture method. These sections met twice a week for one hour and twenty minute lectures and once a week for a fifty minute recitation-demonstration period which yielded four semester credits. For statistical purposes, the control group consisted of an equal number of students, randomly selected from the other three sections of the course, from among those who had completed all the pre-, mid-, post-attitude and cognitive instruments.

All chemistry students were given a computer-generated chemistry achievement examination during the first week of the semester, at the mid-semester point, and during the final week of the Fall Semester. At these same times the students completed a chemistry attitude scale, developed by the author.

All four sections used the same basic textbook.

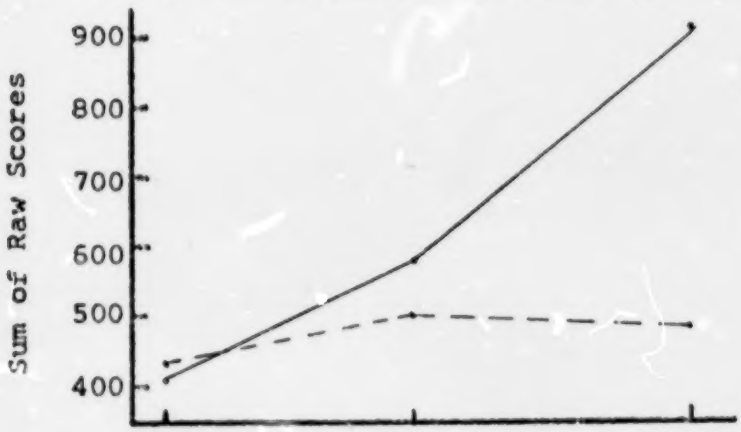
Results - Part One

Achievement and attitude scores were studied using a two factor (A X B) analysis of variance with repeated measures on factor B, followed by a trend analysis. Factor A consisted of the two levels: experimental and control. Factor B consisted of the three levels: pre-test, mid-test, and post-test.

Chemistry Achievement Examination

The results of the above analysis for the chemistry achievement examination are shown in Figure 1 and Table 1.

Figure 1 - Cognitive Trend by Raw Score



Pre	Mid	Post	
412	599	915	Experimental (——)
426	508	481	Control (- - - -)

TABLE 1

ANOVA AXB Trend Analysis - Cognitive: Pre-Mid-Post

Source	SS	df	MS	F
Between Subjects				
A: Groups	1450.66	1	1450.66	29.18**
Error	2883.65	58	49.72	
Within Subjects				
B: Trials	2595.80	2	1297.90	81.11**
AXB: Groups X Trials	1829.90	2	914.95	57.18**
Error	1856.25			
Totals	10616.32	179		

Table 1 is an A X B Analysis of Variarance (ANOVA) with repeated measures on factor B. It shows that, overall, the groups differed significantly ($F=29.18$, $p < .01$) in their learning curves (Figure 1). A Trend analysis showed the overall learning curves to be linear ($F=324.29$, $p < .01$) and that a significant ($F=57.18$,

$p < .01$) group by trials interaction existed. Consequently, the simple effects were examined. A one-way ANOVA was performed on both the experimental and control groups across trials. This is shown in Tables 3 and 4 and Figure 2.

TABLE 2

Means and Standard Deviations for Chemistry Achievement

		Experimental Condition			
Group	Statistic	Pre	Mid	Post	Adjusted Post by ANACOVA
Experimental	Mean	13.73	19.97	30.5	30.57
	S.D.	4.04	6.04	6.03	
Control	Mean	14.2	16.93	16.03	15.96
	S.D.	4.29	5.22	5.34	

Figure 2 - Cognitive Trend by Means

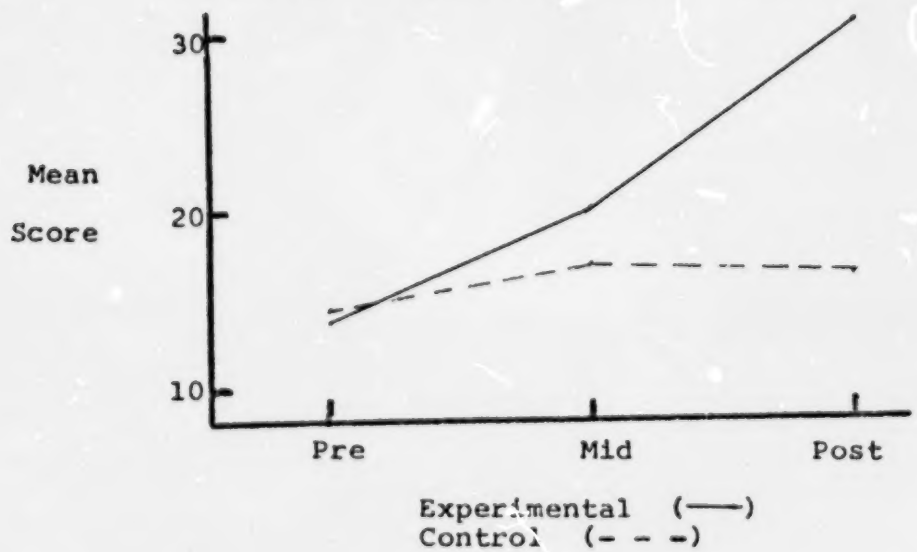


TABLE 3

One Way ANOVA Experimental - Cognitive: Pre-Mid-Post

Source	SS	df	MS	F
Treatments	4309.27	2	2154.64	72.48**
Error	2586.33	87	29.73	
Total	6895.6	89	77.48	

Scheffe Test for Comparison Between All Pairs of Means
Table of F-Ratios (2 and 87 df)

	Pre	Mid
Mid	9.80**	
Post	70.92**	27.99**

Table 3 shows the experimental group to be constantly learning, with post-test results significantly ($F=27.99$, $p < .01$) higher than mid-test results which are significantly higher ($F=9.80$, $p < .01$) than pre-test results.

TABLE 4

One Way ANOVA Control - Cognitive: Pre-Mid-Post

Source	SS	df	MS	F
Treatments	116.42	2	58.21	2.24
Error	2153.63	87	24.75	
Total	2270.05	89		

Table 4 shows no significant difference among the three levels (pre-,mid-,post-) for the control group, i.e. the control group did not demonstrate a statistical increase, or decrease, in their knowledge of chemistry.

An analysis of covariance for the chemistry achievement examination with the pre-test as a covariate was performed. The results are shown in Table 5.

TABLE 5

ANACOVAR Experimental vs. Control on Post-test Cognitive Using Pre-test Cognitive as Covariate

Source	SS	df	MS	F
Between	3190.84	1	3190.84	101.66**
Within	1789.15	57	31.39	
Total	4979.99	58	85.86	

Recap - Sum of Squares

Variation	Pre	df	Post	Pre X Post
Between	3.27	1	3139.27	-101.27
Within	1008.67	58	1882.47	306.80
Total	1011.93	59	5021.73	205.54

No significant difference existed between the two groups at the start of the study (E pre-test mean=13.73; C pre-test mean= 14.2; F=0.19, N.S.) but when post-test results were adjusted (using pre-test as covariate) to reflect initial discrepancies (E adjusted post-test mean=30.57; C adjusted post-test mean= 15.96), the experimental group exhibited more knowledge of chemistry ($F=101.66$, $p < .01$) than did the control group.

Putting Tables 1 through 5 together and looking at Figures 1 and 2, one can state that the experimental and control groups did not differ in their knowledge of chemistry at the start of the study. One can also note that the experimental group constantly increased in their cognitive knowledge of chemistry while the control group remained constant. It was also noted that by the mid-test the experimental group was outperforming the control group, a trend which continued to the conclusion of the study.

Chemistry Attitude Scale

Attitude scores were obtained from a locally developed attitudinal scale which measures student attitude toward chemistry, toward the specific class, and toward college in general. In the discussion of the results which follows, the lower the score, the more positive is the attitude. Student attitude toward chemistry is shown in Figure 3 and Table 7. There were 20 questions on this part of the scale with five possible responses. Average was a "3" and a mean score of 60 would be neutral.

Figure 3 - Affective Chemistry Trend

TABLE 8

Means and Standard Deviations for Chemistry Attitude

		Experimental Condition			
Group	Statistic	Pre	Mid	Post	Adjusted Post by ANACOVA
Experimental	Mean	59.77	56.4	52.3	56.62
	S.D.	11.7	11.3	12.4	
Control	Mean	60.3	61.1	59.2	60.91
	S.D.	12.4	13.8	12.8	

TABLE 7

ANOVA AXB Trend Analysis - Affective Chemistry: Pre-Mid-Post

Source	SS	df	MS	F
Between Subjects				
A: Groups	744.25	1	744.25	1.86
Error	23222,19	58	400.38	
Within Subjects				
B: Trials	576.25	2	288.12	9.05**
AXB: Groups X Trials	317.12	2	158.56	4.98**
Error	3692.00			
Totals	28551.62	179		

Table 7 is an A X B ANOVA with repeated measures of factor B. It shows that, overall, the groups did not differ in their attitude toward chemistry. However, there did exist an attitude shift ($F=9.05$, $p < .01$) during the course of the study and that shift was group dependent (significant A X B, $F=4.98$, $p < .05$). Overall, the trend was linear ($F=34.32$, $p < .01$) with students developing a more positive attitude toward chemistry as the semester proceeded. This shift, however, was group dependent.

The reason for this interaction is apparent when one looks at Table 8, an analysis of covariance on post-test attitude toward chemistry using pre-test attitude toward chemistry as a covariate. No significant difference existed between the two groups in attitude at the beginning of the study (E pre-test affective mean= 59.77; C pre-test affective mean=60.3; $F=0.03$, N.S.) but when the post-test affective measures were adjusted (using pre-test measures as covariate) to reflect beginning affective differences (E adjusted post-test affective mean=56.62; C adjusted post-test affective mean=60.91; $F=4.51$, $p < .05$), one finds the experimental group liking chemistry more than the control group ($F=9.31$, $p < .01$).

TABLE 8

ANACOVAR Experimental vs. Control on Post-test Affective Chemistry Using Pre-test Affective as Covariate

Source	SS	df	MS	F
Between	635.06	1	635.06	9.31**
Within	3889.66	57	68.24	
Total	4524.57	58	78.01	

Recap - Sum of Squares

Variation	Pre	df	Post	Pre X Post
Between	4.28	1	721.06	55.47
Within	8473.66	58	9269.66	6752
Total	8477.94	59	9990.72	6807.47

Next, the student attitude toward their specific chemistry class were measured, experimental vs. control. This part of the scale consisted of six questions. The results of this analysis are shown in Figure 5 and Tables 9 and 10. Again the lower the test score, the more positive the attitude.

Figure 5 - Affective Class Trend by Raw Score

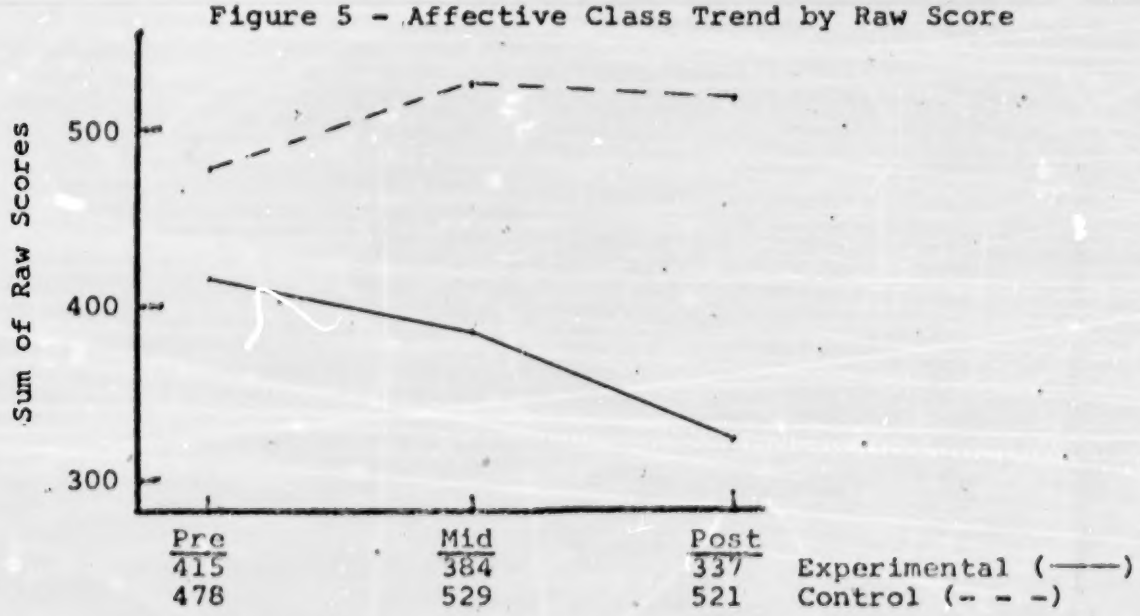


TABLE 9

Means and Standard Deviations for Class Attitude

		Experimental Condition			
Group	Statistic	Pre	Mid	Post	Adjusted Post by ANACOVA
Experimental	Mean	13.83	12.8	11.23	11.76
	S.D.	3.8	3.1	3.6	
Control	Mean	15.9	17.6	17.4	16.84
	S.D.	2.9	4.1	3.6	

TABLE 10

ANOVA AXB Trend Analysis - Class Attitude: Pre-Mid-Post

Source	SS	df	MS	F
Between Subjects				
A: Groups	853.69	1	853.69	32.65**
Error	1516.45	58	26.15	
Within Subjects				
B: Trials	25.83	2	12.91	2.24
AXB: Groups X Trials	127.15	2	63.57	11.05**
Error	667.67			
Totals	3190	179		

Table 10 is an A X B ANOVA with repeated measures on factor B. It shows, overall, a significant difference ($F=32.65$, $p < .01$) between the groups as to their attitude toward their chemistry class. This attitude was constant and did not depend upon the time period (non-significant trials). There existed a significant Group by Trial ($F=11.05$, $p < .01$) interaction. Consequently, applicable simple effects were examined. These are shown in Figure 6 and Tables 11 and 12.

Figure 6 - Affective Class Trend

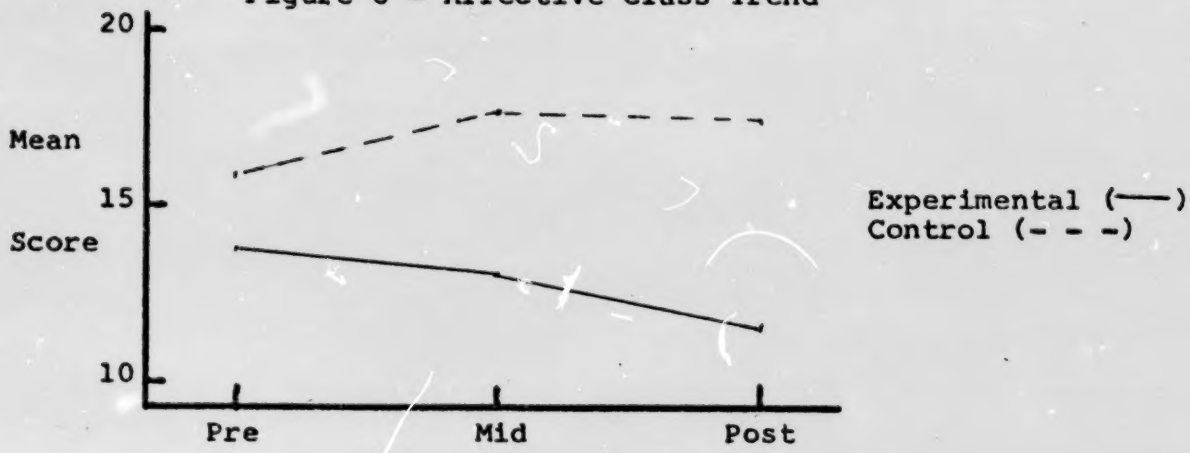


TABLE 11

One Way ANOVA Experimental - Affective Class: Pre-Mid-Post

Source	SS	df	MS	F
Treatments	102.82	2	51.41	4.12**
Error	1086.33	87	12.49	
Total	1189.16	89	13.36	

Scheffe Test for Comparison Between All Pairs of Means
Table of F-Ratios (2 and 87 df)

	Pre	Mid
Mid	0.641	
Post	4.06**	1.47

TABLE 12

One Way ANOVA Control - Affective Class: Pre-Mid-Post

Source	SS	df	MS	F
Treatments	50.16	2	25.08	1.99
Error	1097.8	87	12.62	
Total	1147.96	89		

Table 11 shows that the experimental class significantly ($F=4.12$, $p<.01$) changed in the direction of a more positive attitude toward the chemistry class during the study. Attitude at the conclusion of the study was significantly ($F=4.06$, $p<.05$) more positive than at the beginning of the study. The control

group (Table 12) did not experience a significant change in attitude (F=1.99, N.S.).

Performing an analysis of covariance on post-test attitudes toward the chemistry class, using pre-test attitude measures as a covariate, yielded Table 13.

TABLE 13

ANACOVAR Experimental vs. Control on Post-test Affective Chemistry Class Using Pre-test Affective as Covariate

Source	SS	df	MS	F
Between	353.81	1	353.81	34.96**
Within	576.94	57	10.12	
Total	930.75	58	16.05	

Recap - Sum of Squares

Variation	Pre	df	Post	Pre X Post
Between	66.15	1	564.27	193.20
Within	682.03	58	746.33	339.90
Total	748.18	59	1310.6	533.1

Thus, the experimental group began (E class attitude mean=13.83 vs. C class attitude mean=15.9; F=5.63, $p < .05$), and ended (E class attitude mean=11.23 vs. C class attitude mean=17.4; F=43.85, $p < .01$) the study with a more positive attitude toward their chemistry class than did the control students. When the post-test affective chemistry class experimental and control scores were adjusted for beginning differences (E adjusted mean=11.76 vs. C adjusted mean=16.84), an analysis of covariance showed (F=34.96, $p < .01$) the experimental group exhibiting a more positive attitude toward their chemistry class than did the control group. This difference also existed at mid-test time.

There was no significant difference between the experimental and control groups in their general attitude toward college as measured by this scale. This is seen in Table 14.

TABLE 14

ANOVA AXB Trend Analysis - College Attitude: Pre-Mid-Post

Source	SS	df	MS	F
Between Subjects				
A:Groups	0.0	1	0.0	0.0
Error	1572.14	58	27.11	
Within Subjects				
B:Trials	8.40	2	4.20	0.56
AXB: Groups X Trials	12.40	2	6.20	0.82
Error	873.88			
Totals	2466.80	179		

Summary - Part One

In summary, the results of Part One showed that the ILS Chemistry students liked their class better than did the traditional chemistry students. This attitude also held for chemistry in general. Assuming test validity, there exists evidence to suggest that the ILS Chemistry students learned more chemistry than did their traditional counterparts. However, this interpretation must be dampened somewhat when one realizes that performance on the cognitive instrument resulted in a grade in the experimental class only and with the control students knowing that their examination did not count. It should also be noted that seven students had not yet finished ILS Che 100 and hence were omitted from this part of the study. These seven students could possibly alter the reported outcomes.

Results - Part Two

During the Spring Semester of 1974 the American Chemical Society Inorganic-Organic-Biological Chemistry Test, Form 1974 was administered to all students enrolled in Che 100 as a post test only. This semester there were three instructors teaching

the four sections. The experimental group once again was the ILS course taught by Professor Torop. For statistical purposes there were two control groups - one for each of the other two instructors. A summary of the means and standard deviations for this instrument is presented in Table 15. An analysis of variance were performed for each subtest and are presented in Tables 16, 17 and 18. The obtained F ratio of 2.31 for the Inorganic Subtest and F ratio of 1.39 for the Organic Subtest were not significant at the .01 level of significance. These results suggest that the ILS approach produced cognitive results in the inorganic and organic chemistry portion of the course at least as good as those produced by the traditional classrooms.

Analysis of variance for the Biological Subtest, however, showed a significant difference at the .01 level. The results of *t*-tests between the means, presented in Table 19, show that both control groups scored significantly higher than the experimental group on the Biological Chemistry Subtest. This suggests that some revision is necessary in this area of the ILS course.

TABLE 16

Means and Standard Deviations for American Chemical Society Inorganic-Organic-Biological Chemistry Test, Form 1974

Subtest	Group	Mean	Standard Deviation
Inorganic	Experimental	24.84	5.57
	Control 1	22.52	7.42
	Control 2	26.4	6.14
Organic	Experimental	17.72	4.74
	Control 1	17.56	5.36
	Control 2	19.84	6.02
Biological	Experimental	18.6	5.65
	Control 1	21.2	3.84
	Control 2	23.44	5.61

TABLE 17

Analysis of Variance for Inorganic Subtest

Source	SS	df	MS	F
Treatment	190.59	2	95.30	2.31
Error	2971.59	72	41.27	
Total	3162.19	74		

TABLE 18

Analysis of Variance for Organic Subtest

Source	SS	df	MS	F
Treatment	80.99	2	40.49	1.39
Error	2102.56	72	29.20	
Total	2183.55	74		

TABLE 19

Analysis of Variance for Biological Subtest

Source	SS	df	MS	F
Treatment	192.03	2	96.01	3.68**
Error	1876.16	72	26.06	
Total	2068.19	74		

TABLE 20

t-Tests for Biological Subtest

Groups	T-ratio	df	Probability
Experimental & Control 1	-1.90	48	.03
Experimental & Control 2	-2.41	48	.01
Control 1 & Control 2	-0.91	48	.31

Results - Part Three

Finally, a rating scale (see Appendix Two) developed by Professor Torop was administered anonymously to ascertain student evaluation of the course. An item analysis of the course evaluation is presented in Table 21. Questions 32 to 40 were not applicable because there was no regular laboratory associated with this course. Students responded to these questions in terms of the recitation-demonstration period even though the questions were somewhat irrelevant.

Examination of the data reveals that the majority of items were rated above average or better by at least 75% of the students. Very few students expressed dissatisfaction with the instructional method or the course materials. These appear to be very favorable evaluations for a non-major required course for the majority of students.

TABLE 21

ITEM RESPONSES — ILS COURSE EVALUATION

ITEM NR	1	PCNT	2	PCNT	3	PCNT	4	PCNT	5	PCNT	INDEX
1	28	71.8	4	10.3	6	15.4	0	0.0	0	0.0	1.385
2	15	38.5	15	38.5	7	17.9	1	2.6	0	0.0	1.795
3	12	30.8	13	33.3	10	25.6	2	5.1	1	2.6	2.077
4	36	92.3	2	5.1	0	0.0	0	0.0	0	0.0	1.026
5	11	28.2	15	38.5	8	20.5	1	2.6	3	7.7	2.154
6	32	82.1	3	7.7	2	5.1	0	0.0	1	2.6	1.256
7	24	61.5	11	28.2	3	7.7	0	0.0	0	0.0	1.410
8	26	66.7	8	20.5	3	7.7	1	2.6	0	0.0	1.410
9	22	56.4	4	10.3	4	10.3	3	7.7	5	12.8	2.025
10	22	56.4	8	20.5	8	20.5	0	0.0	0	0.0	1.590
11	25	64.1	11	28.2	2	5.1	0	0.0	0	0.0	1.359
12	13	33.3	12	30.8	11	28.2	2	5.1	0	0.0	2.000
13	26	66.7	11	28.2	1	2.6	0	0.0	0	0.0	1.308
14	23	59.0	11	28.2	2	5.1	1	2.6	1	2.6	1.538
15	16	41.0	15	38.5	7	17.9	0	0.0	0	0.0	1.718
16	19	48.7	14	35.9	5	12.8	0	0.0	0	0.0	1.590
17	22	56.4	9	23.1	5	12.8	2	5.1	0	0.0	1.615
18	23	59.0	9	23.1	6	15.4	0	0.0	0	0.0	1.513
19	22	56.4	10	25.6	4	10.3	2	5.1	0	0.0	1.590
20	17	43.6	12	30.8	6	15.4	2	5.1	1	2.6	1.846
21	14	35.9	16	41.0	4	10.3	2	5.1	2	5.1	1.949
22	7	17.9	6	15.4	15	38.5	0	0.0	10	25.6	2.923
23	29	74.4	4	10.3	3	7.7	2	5.1	0	0.0	1.385
24	29	74.4	4	10.3	5	12.8	0	0.0	0	0.0	1.333
25	12	30.8	7	17.9	12	30.8	2	5.1	5	12.8	2.436
26	25	64.1	8	20.5	5	12.8	0	0.0	0	0.0	1.436
27	25	64.1	10	25.6	3	7.7	0	0.0	0	0.0	1.385
28	27	69.2	8	20.5	3	7.7	0	0.0	0	0.0	1.333
29	22	56.4	11	28.2	5	12.8	0	0.0	0	0.0	1.513
30	9	23.1	20	51.3	8	20.5	1	2.6	0	0.0	1.974
31	17	43.6	16	41.0	5	12.8	0	0.0	0	0.0	1.641
32	4	10.3	4	10.3	30	76.9	0	0.0	0	0.0	2.615
33	4	10.3	6	15.4	27	69.2	1	2.6	0	0.0	2.590
34	7	17.9	7	17.9	24	61.5	0	0.0	0	0.0	2.385
35	8	20.5	5	12.8	25	64.1	0	0.0	0	0.0	2.385
36	6	15.4	4	10.3	28	71.8	0	0.0	0	0.0	2.513
37	3	7.7	3	7.7	31	79.5	0	0.0	1	2.6	2.744
38	3	7.7	3	7.7	31	79.5	1	2.6	0	0.0	2.718
39	1	2.6	5	12.8	32	82.1	0	0.0	0	0.0	2.744
40	5	12.8	3	7.7	27	69.2	1	2.6	2	5.1	2.718

Perhaps more revealing than the mean indices are some actual comments written by students in answer to questions 41 to 44.

> I learned to do chemistry on my own, accept responsibility, and no class.
>
> Each student could perform at his own pace and on his own. I personally thought this was an advantage for me. It made it more interesting to me. The course was a challange.
>
> The ability to learn and discipline yourself to do work. This made one realize that this couse, like all others, were mostly dependent on students working to do it.
>
> The best part of this course was being able to work at your own speed without being pushed or nagged about doing work. There should be more courses like this one offered to the student. I feel a lot more is learned and the student feels that he wants to learn on his own free will.
>
> This is probably one of the only science courses which I have had or am going to have that I enjoyed. I think it is a good and worthy concept.
>
> I thought the course was great! And would not mind others of the same kind.
>
> This is an excellent course. As a student never having chemistry, I find that I am learning and more important understanding the chemistry.
>
> Instructor was available somewhere, at home, school, etc. almost anytime, told us when he wouldn't be in, informed us on difficulties through letters to dorm, showed genuine concern and enthusiasm, explained any little thing any student felt confused on and it was great for those who like to work at their own pace.

Negative comments centered around hardware failures and limited access at times to the computer terminals which interfered with the self-paced aspect of the course.

Conclusion

In conclusion, the cognitive achievement of ILS chemistry students is at least as good as their traditional counterparts. The significant difference occurs in the attitudinal domain

where students report highly favorable attitudes toward the course and increased confidence in their ability to deal with difficult material. The format of the course, in allowing for the increased interaction between professor and students -- particularly during the scheduled conference times -- provides the opportunity to observe significant growth for many students in the areas of self-confidence and personal responsibility.

A final advantage in having this type of course occurs in permitting students experiencing academic difficulty with the major level general chemistry course to transfer to Che 100 -- thereby not losing credits, avoiding a failure grade on their record, learning the fundamentals needed to continue in chemistry, and improving their self-concept.

Acknowledgement

Dr. Thomas A. Egan, Associate Professor of Mathematics, is responsible for the computer program CMI and his assistance in the statistical analysis is also appreciated. The computer program used in the statistical analysis is $STAT which was written by Professor Egan.

Appendix One

TOROP'S CHEMISTRY/COLLEGE ATTITUDE INSTRUMENT

Directions: This is a questionnaire which will assess your feelings toward chemistry and college in general, and this course in particular.

On the digitek answer sheet provided, and using the following scale:

A. Strongly Agree

B. Agree

C. Neutral (somewhat agree / somewhat disagree)

D. Disagree

E. Strongly Disagree

indicate the extent of your agreement with each statement made. Please use a #2 pencil only.

••••••

A. Strongly Agree
B. Agree
C. Neutral somewhat agree somewhat disagree
D. Disagree
E. Strongly Disagree

****

16. It makes me nervous to even think about having to do a chemistry problem.
17. I have never liked chemistry and it is my most dreaded subject.
18. I am happier in a chemistry class than in any other class.
19. I feel at ease in chemistry and I like it very much.
20. I feel a definite positive reaction to chemistry; it is enjoyable.
21. I enjoy college.
22. College is fascinating.
23. College is stimulating.
24. College is interesting.
25. College is useful.
26. College is dull.
27. This chemistry class is interesting.
28. This chemistry class in enjoyable.
29. This chemistry class is useful.
30. This chemistry class is comfortable.
31. This chemistry class is dull.
32. This chemistry class is much better than any of the past.

© William Torop 1974

Appendix Two

Part I. Evaluate the instruction by using the following code:

A = Almost Always

B = Frequently

C = Average

D = Occasionally

E = Hardly Ever

1. The instructor was well prepared each day.
2. The instructor presented material in a clear and logical manner.
3. The instructor stimulated students to think.
4. The instructor was enthusiastic about the subject.
5. The instructor stimulated my interest in the subject.
6. The instructor was available for consultation outside of class.
7. The instructor was sensitive to student difficulties.
8. The instructor was fair in dealing with students.
9. The instructor was impartial in dealing with students.
10. The instructor began class promptly.
11. The instructor provided opportunities for asking questions.
12. The instructor was receptive to different ideas and diverse viewpoints.
13. The objectives of the course were adequately explained.
14. The content of the course was appropriate to the objectives of the course.
15. The course material was presented at a level which I could understand.
16. The course consisted of a variety of materials and activities.
17. The course material was adequately paced.
18. The assignments were clearly specified.
19. The assignments were closely related to the course materials.
20. The assignments were necessary to the understanding of the subject.
21. The assignments were challenging.
22. The assignments were returned promptly with comment or review.
23. Examinations and quizes provided balanced coverage of major course topics.
24. Examinations and quizes were returned promptly.
25. Examinations and quizes were returned with comment or review.
26. Evaluation procesures were clearly defined.
27. Examinations and quizes were fair.
28. My grades accurately reflect my performance in this course.

Part II. Answer Questions 29-31 using the following code:

A = Superior
B = Above Average
C = Average
D = Below Average
E = Poor

29. How would you rate the teaching ability of this instructor?

30. How would you rate the overall value of this course?

31. How would you rate the assessment techniques (grading) in this course?

Part III. LABORATORY SECTIONS ONLY. Use the following code:

A = Almost Always
B = Frequently
C = Average
D = Occasionally
E = Hardly Ever

32. The materials and equipment were available at the beginning of the laboratory period.

33. The laboratory procedures were explained before the experiments were started.

34. The instructor was available and provided help during the laboratory period.

35. The instructor showed concern for the student's progress in the laboratory.

36. The laboratory appeared to be well integrated with the lecture portion of the course.

37. Laboratory reports were graded and returned promptly.

38. Laboratory reports were evaluated in a consistent and fair manner.

39. The laboratory grades reflects your performance and comprehension of the experiments.

40. The laboratory work has added to my understanding of the subject.

Part IV. EVERYONE. Please answers Questions 41-44 on the back of the answer sheet.

41. The best part of this course was:

42. The worst part of this course was:

43. The most important change to make is:

44. Additional comments or comments on specific questions (1-40), especially the questions with negative responses: (identify by question number)